



RADTRAD – Past, Present, and Future

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Objective

- The purpose is to present an overview of the development of SNAP/RADTRAD including the history, present status and future plans.

Purpose of SNAP/RADTRAD

- Purpose of SNAP/RADTRAD is to determine the dose from a release of radionuclides during a design basis accident to the following locations:
 - Exclusion Area Boundary (EAB)
 - Low Population Zone (LPZ)
 - Control Room (or Emergency Offsite Facility)
- Focus of SNAP/RADTRAD is licensing analysis to show compliance with nuclear plant siting and control room dose limits for various LOCA and non-LOCA accidents.

Background of SNAP/RADTAD

About 10 years ago, NRC decided to incorporate RADTRAD into the SNAP graphical user interface due to maintenance difficulties:

- RADTRAD 3.10 was translated into JAVA from Fortran.
- Additional output (text based) was incorporated into SNAP/RADTRAD.
- The original Visual Basic GUI was converted to a SNAP plugin to provide GUI capability for developing RADTRAD models. Input checking was incorporated.
- Initial verification and validation was done on SNAP/RADTRAD.
- RADTRAD 3.03 status change to a legacy code with distribution by Radiation Safety Information Computation Center (RSICC) (<https://rsicc.ornl.gov>).

Background of SNAP/RADTRAD

SNAP/RADTRAD is currently being used both domestically at the NRC and at licensee organizations as well as internationally.

- SNAP/RADTRAD is available to any organization that is a member of RAMP.
 - Membership privileges include access to the latest code executables, documentation on the use of the code and test reports.
- SNAP/RADTRAD training was provided in 2014 through 2018 either at the NRC or internationally (South Africa, Taiwan, UAE)
- NRC is continuing development and maintenance of both the SNAP GUI and the RADTRAD code.



Current Status

SNAP/RADTRAD is distributed in separate program packages:

- SNAP with the RADTRAD plug-in – basically the graphical user interface package. Maintained by Applied Programming Technology, Inc.
 - The RADTRAD plug-in provides the code to allow RADTRAD-specific features to be displayed in the SNAP Model Editor.
 - Default data used in RADTRAD is also programmed into the RADTRAD plug-in code.
- RADTRAD-AC – the RADTRAD analytical code (AC) that performs the actual radionuclide concentrations and dose calculations. Maintained by ISL, Inc.
 - Input files used by RADTRAD are exported by the Model Editor plugin.
- APTPlot – a plotting package that permits the user to plot dose results. Maintained by Applied Programming Technology, Inc.



Current Status

Other Changes made to the SNAP/RADTRAD code package:

- The entire ICRP-38 radionuclide set has been incorporated into SNAP/RADTRAD.
 - The user can make changes to the radionuclide library through the Model Editor, but usually not necessary.
- The ICRP-30 dose conversion factor library tabulated in the Federal Guidance Report No. 11 and No.12 published by the U.S. Environmental Protection Agency (EPA) has been incorporated into SNAP/RADTRAD.
 - User can specify DCFs if desired through the SNAP interface.



Current Status

- The ability to model non-LOCA accidents has been made easier:
 - Source term models for fuel handling accidents, rod ejection or control rod drop accidents have been added based on guidance in NRC Regulatory Guide 1.183.
 - Models for determining the reactor coolant inventory activity have been added so that tube ruptures and other reactor coolant related accidents can be modeled. Pre-incident and co-incident iodine spiking can be modeled.



Current Status

- Other features in the SNAP/RADTRAD code package::
 - Multiple source terms can be analyzed
 - Multiple release pathways can be analyzed
 - Plotting of results through APTPlot available
 - Other SNAP features (Ex. multiple problems, parameter variation, model comparison) are available.
- Removal models (natural deposition, sprays, filters) are generally unchanged from earlier RADTRAD versions (V3.03).



SNAP/RADTRAD Model Editor

- SNAP/RADTRAD input specification revolves around the use of the SNAP Model Editor
 - Up-to-date input specification with drag and drop interface
 - Good input error checking features
- Model Editor presents a standard interface across a large number of NRC codes.
 - Codes include TRACE and MELCOR, SCALE among others



SNAP/RADTRAD Model Editor (Test 23)

Model Editor 2.6.0

File Edit Tools Window Help

Test23.med - (unnamed)

- Model Options
- Nuclide Data
- Sources [1]
- Compartment [5]
- Pathways [10]
- Dose Locations [3]
- Natural Deposition [1]
- Filters [4]
- Sprays [1]
- XIQ Tables [3]
- Connections [26]
- Job Streams [1]
- Numerics [0]
- Views [2]

Navigator Window

General

No Properties Available

Properties Window

Lock

RADTRAD Assessment Case Test23

Unsprayed to Sprayed 4

Sprayed to Unsprayed 1

Sprayed to Annulus 2

Sprayed to Environment 3

Unsprayed Region 2

Unsprayed to Environment 6

Unsprayed to Annulus 5

Annulus 3

Annulus to Environment 7

Environment 4

Exhaust from CR to Environment 10

Unfiltered-Environment to CR 9

Filter 2-Environment to CR 8

Control Room 5

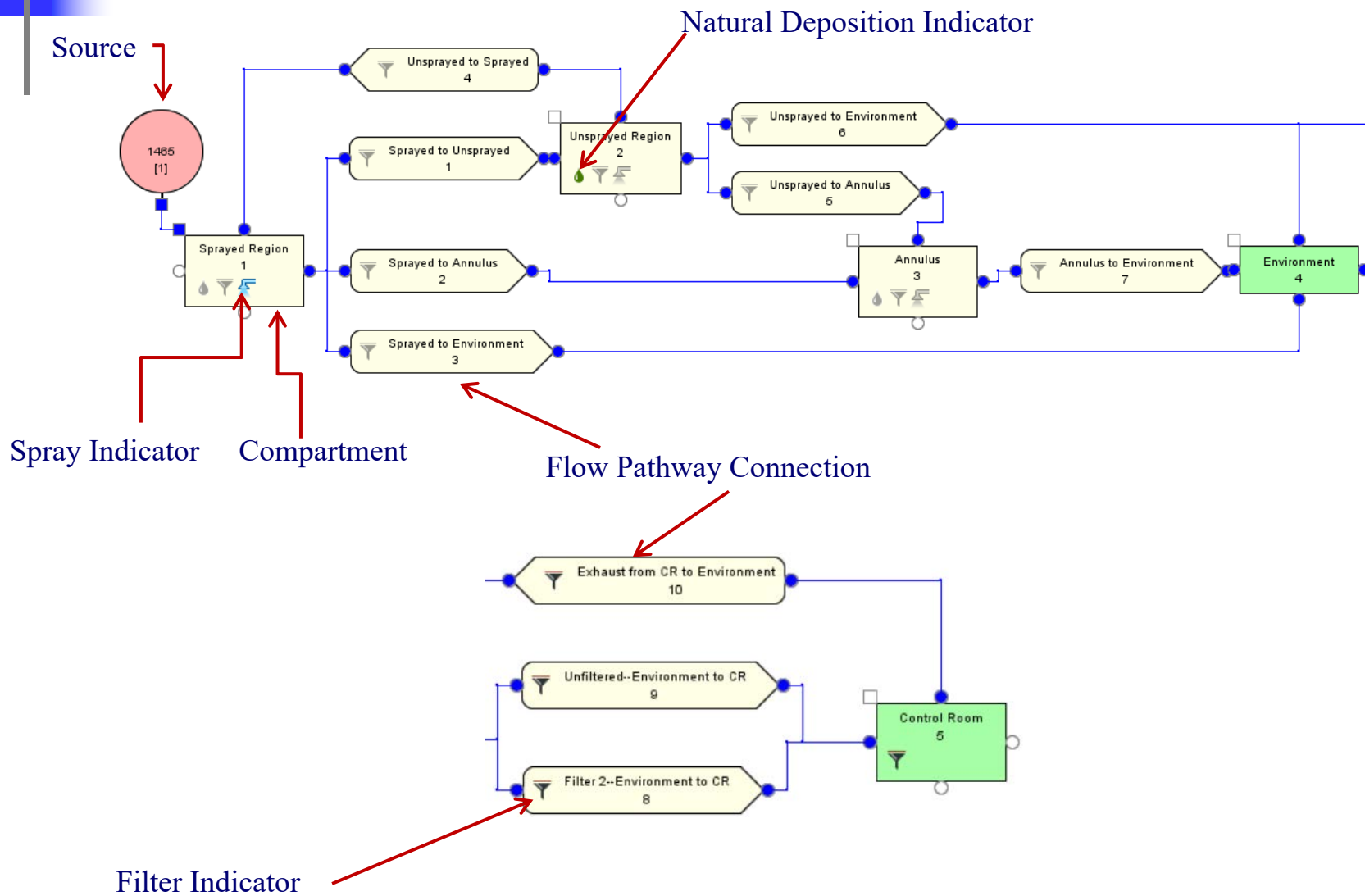
View Window

Message Window

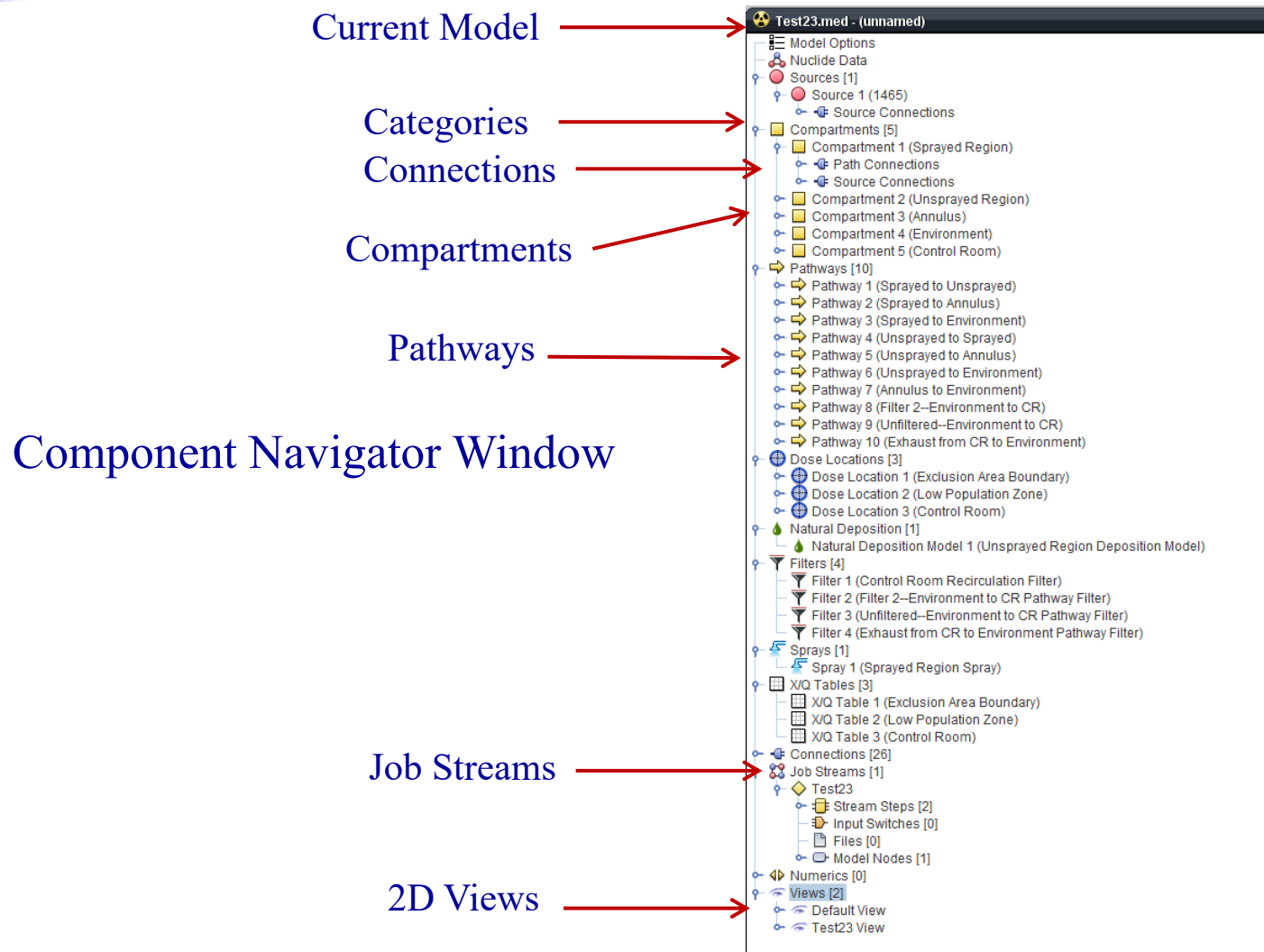
Messages

- Note: Opening file C:\Work\Current\RADTRAD4\Training\Training_March 2018 Abu Dhabi\Samples\Test23\Test23.med
- Note: Loading C:\Work\Current\RADTRAD4\Training\Training_March 2018 Abu Dhabi\Samples\Test23\Test23.med please wait...
- Note: Open Complete.

SNAP/RADTRAD Model Editor (Test 23)

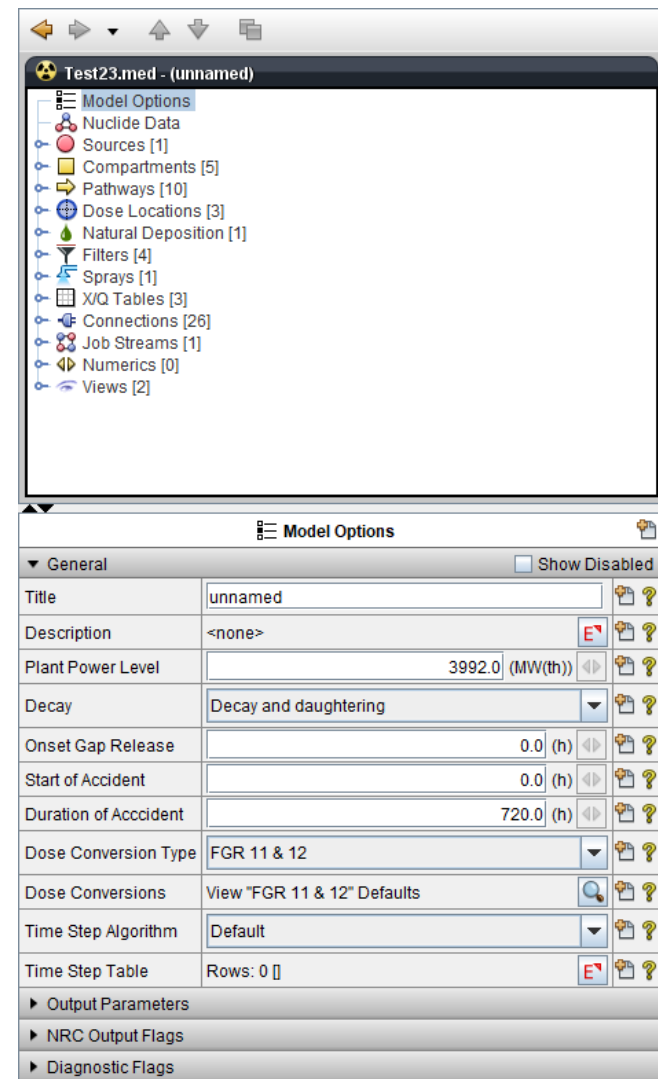


SNAP/RADTRAD Model Editor (Test 23)



SNAP/RADTRAD Model Editor (Test 23)

General Model Options



The screenshot displays the 'Model Options' dialog box for a model named 'Test23.med - (unnamed)'. The dialog is organized into a tree view on the left and a detailed settings panel on the right.

Tree View (Left):

- Model Options (selected)
- Nuclide Data
- Sources [1]
- Compartments [5]
- Pathways [10]
- Dose Locations [3]
- Natural Deposition [1]
- Filters [4]
- Sprays [1]
- X/Q Tables [3]
- Connections [26]
- Job Streams [1]
- Numerics [0]
- Views [2]

Model Options Panel (Right):

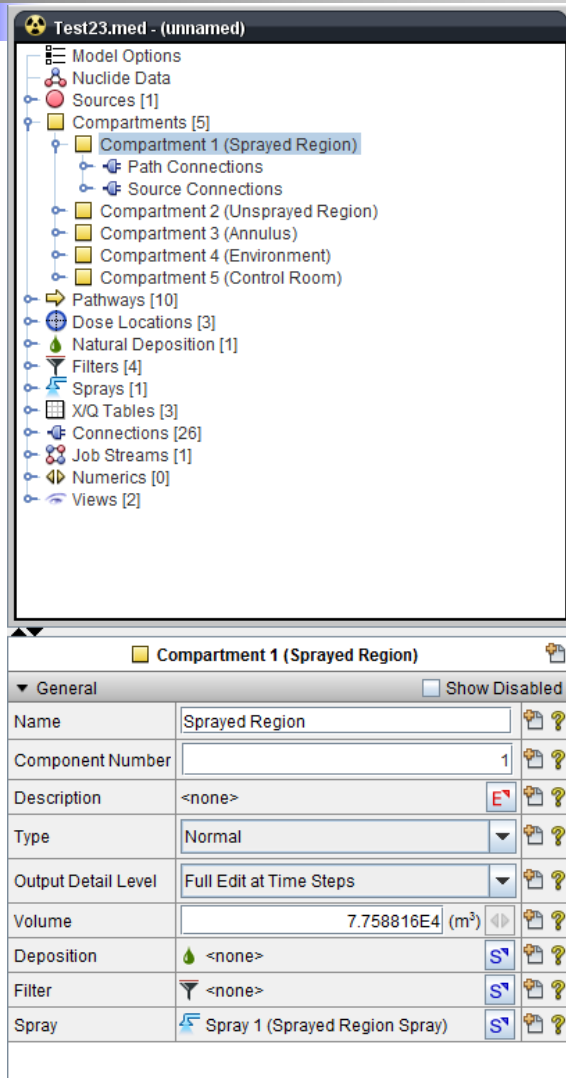
General (Show Disabled)

Title	unnamed	[Icon]	[Icon]
Description	<none>	[Icon]	[Icon]
Plant Power Level	3992.0 (MW(th))	[Icon]	[Icon]
Decay	Decay and daughtering	[Icon]	[Icon]
Onset Gap Release	0.0 (h)	[Icon]	[Icon]
Start of Accident	0.0 (h)	[Icon]	[Icon]
Duration of Accident	720.0 (h)	[Icon]	[Icon]
Dose Conversion Type	FGR 11 & 12	[Icon]	[Icon]
Dose Conversions	View "FGR 11 & 12" Defaults	[Icon]	[Icon]
Time Step Algorithm	Default	[Icon]	[Icon]
Time Step Table	Rows: 0 []	[Icon]	[Icon]

Other Sections:

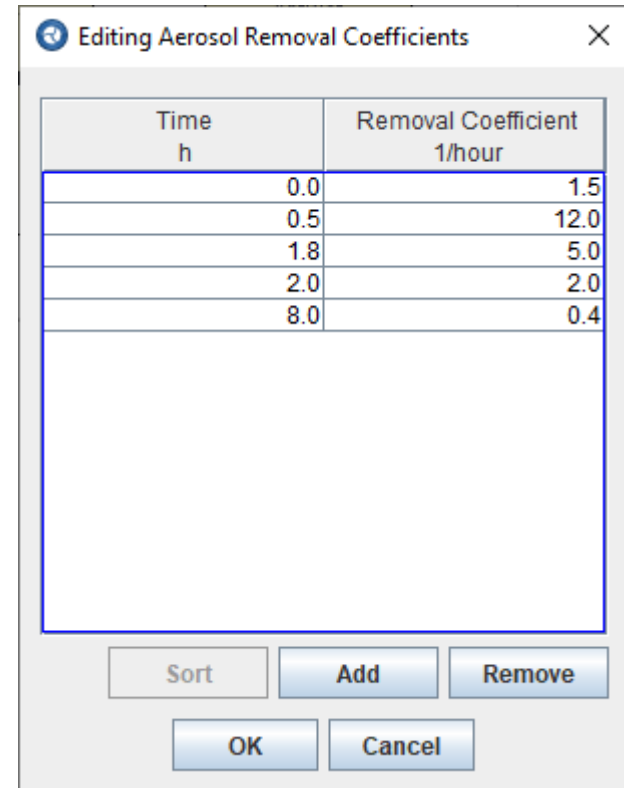
- Output Parameters
- NRG Output Flags
- Diagnostic Flags

SNAP/RADTRAD Model Editor (Test 23)



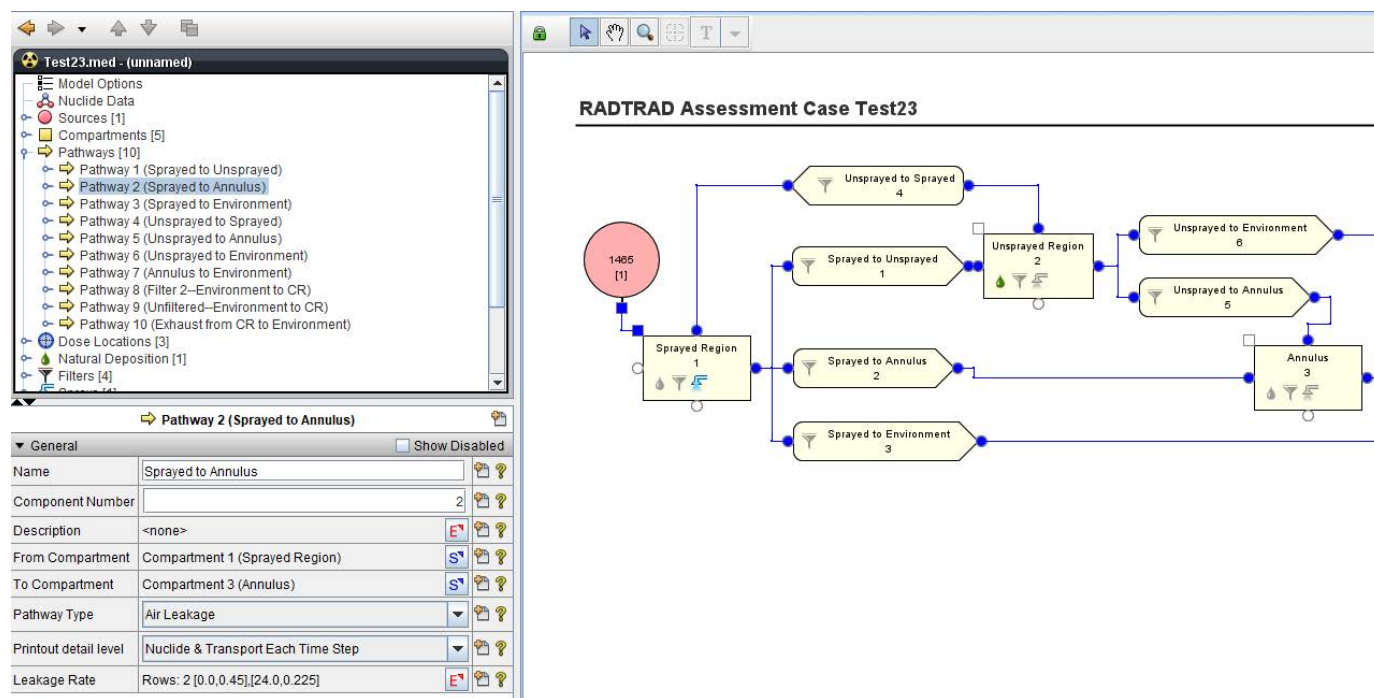
Navigator Window

Properties Window



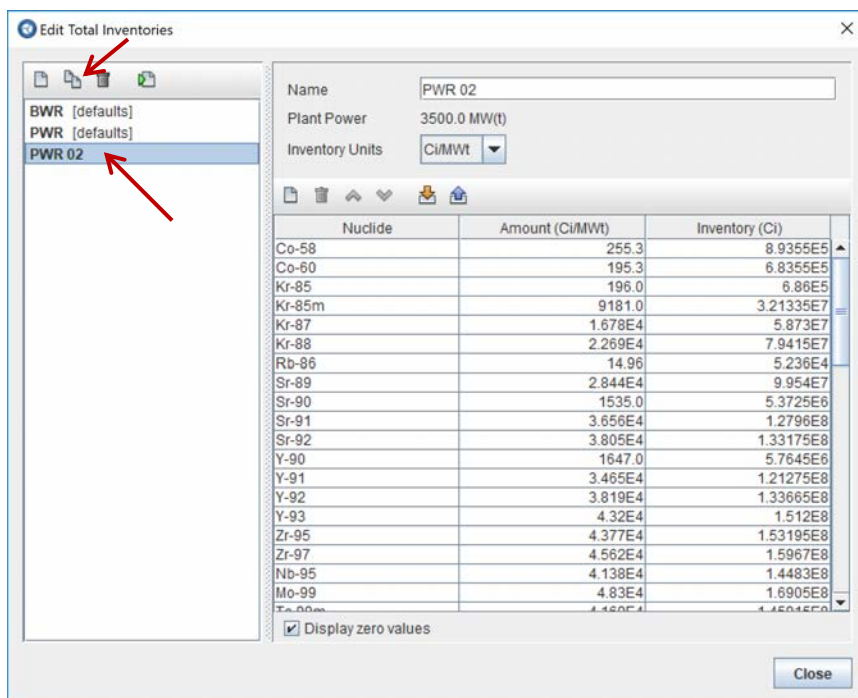
Typical Input Entry Window

SNAP/RADTRAD Model Editor (Test 23)

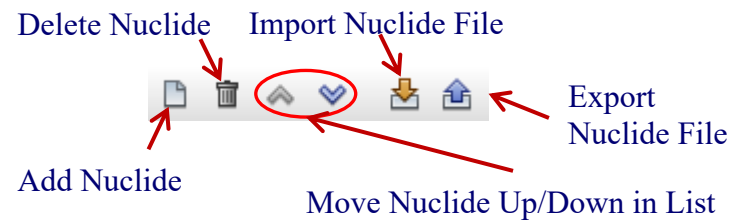


Flow Pathway Input

SNAP/RADTRAD Model Editor (Test 23)

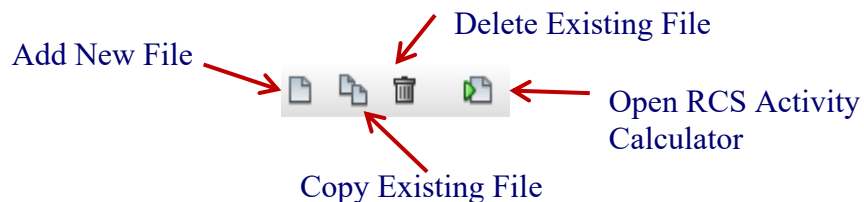


Nuclide Editing Icons



- The user can also add a new file clicking on the Add New File.

File Editing Icons



Select Nuclides

Select nuclide(s)

Gd-153 HL:2.09088E7 mass:152.9217

Gd-159 HL:6.6816E4 mass:158.9264

Ge-66 HL:8172.0 mass:65.93385

Ge-67 HL:1122.0 mass:66.93274

Ge-68 HL:2.48832E7 mass:67.9281

Ge-69 HL:1.4058E5 mass:68.92797

Ge-71 HL:1.01952E6 mass:70.92495

Ge-75 HL:4966.8 mass:74.92286

Ge-77 HL:4.068E4 mass:76.92355

Ge-78 HL:5220.0 mass:77.92285

H-3 HL:3.894696E8 mass:3.016049

Hf-170 HL:5.7636E4 mass:169.9397

Hf-172 HL:5.897232E7 mass:171.9395

Hf-173 HL:8.64E4 mass:172.9407

Hf-175 HL:6.048E6 mass:174.9415

Hf-177m HL:3084.0 mass:176.9432

Hf-178m HL:9.77616E8 mass:177.9437

Hf-179m HL:2.16864E6 mass:178.9458

OK

Cancel

Test23.med - (unnamed)

Model Options

Nuclide Data

Sources [1]

Source 1 (1465)

Source Connections

Compartments [5]

Pathways [10]

Dose Locations [3]

Natural Deposition [1]

Filters [4]

Sprays [1]

X/Q Tables [3]

Connections [26]

Job Streams [1]

Numerics [0]

Views [2]

Source 1 (1465)

General

Name

1465

Component Number

1

Description

<none>

Source Scenarios

[1] active: unnamed

Source Term Fraction

1.0 (-)

Iodine Physical Form

NUREG-1465

Aerosol Fraction

0.95 (-)

Elemental Fraction

0.0485 (-)

Organic Fraction

1.5E-3 (-)

Compartments

Compartment 1 (Sprayed Region)

Edit Total Inventories

Name

PWR 02

Plant Power

3500.0 MW(t)

Inventory Units

Ci/MWt

Nuclide	Amount (Ci/MWt)	Inventory (Ci)
H-3	1000.0	3.5E6
Co-58	255.3	8.9355E5
Co-60	195.3	6.8355E5
Ko-85	196.0	6.86E5
Ko-85m	9181.0	3.21335E7
Kr-87	1.678E4	5.873E7
Kr-88	2.269E4	7.9415E7
Rb-86	14.96	5.236E4
Sr-89	2.844E4	9.954E7
Sr-90	1535.0	5.3725E6
Sr-91	3.656E4	1.2796E8
Sr-92	3.805E4	1.33175E8
Y-90	1647.0	5.7645E6
Y-91	3.465E4	1.21275E8
Y-92	3.819E4	1.33665E8
Y-93	4.32E4	1.512E8
Zr-95	4.377E4	1.53195E8
Zr-97	4.562E4	1.5967E8
Nb-95	4.138E4	1.4483E8

Display zero values

Close

Nuclide Input

Source Location and Chemical Form Input

SNAP/RADTRAD Model Editor (Test 23)

Test23.med - (unnamed)**

- Source 1 (1465)
 - Source Connections
- Compartments [5]
 - Compartment 1 (Sprayed Region)
 - Compartment 2 (Unsprayed Region)
 - Compartment 3 (Annulus)
 - Compartment 4 (Environment)
 - Compartment 5 (Control Room)
- Pathways [10]
 - Dose Locations [3]
 - Natural Deposition [1]
 - Filters [4]
 - Sprays [1]
 - Spray 1 (Sprayed Region Spray)
- X/Q Tables [3]
 - X/Q Table 1 (Exclusion Area Boundary)
 - X/Q Table 2 (Low Population Zone)**
 - X/Q Table 3 (Control Room)

X/Q Table 2 (Low Population Zone)

General ☐ Show Disabled

Name: Low Population Zone

Component Number: 2

Description: <none>

X/Q Table: Rows: 4 [0.0,1.35E-4],[8.0,1.0E-4],[24.0,5.4E-5],[96.0,2.2E-5]

Onsite X/Q Table Map

	Intake from Environment	
↓ Pathways →	[8] Filter 2--Environment to CR	[9] Unfiltered--Environment to CR
[3] Sprayed to Environment	X/Q Table 3 (Control Room)	X/Q Table 3 (Control Room)
[6] Unsprayed to Environment	X/Q Table 3 (Control Room)	X/Q Table 3 (Control Room)
[7] Annulus to Environment	X/Q Table 3 (Control Room)	X/Q Table 3 (Control Room)
[10] Exhaust from CR to Environment		

Release to Environment

Help OK Cancel

Editing X/Q Table

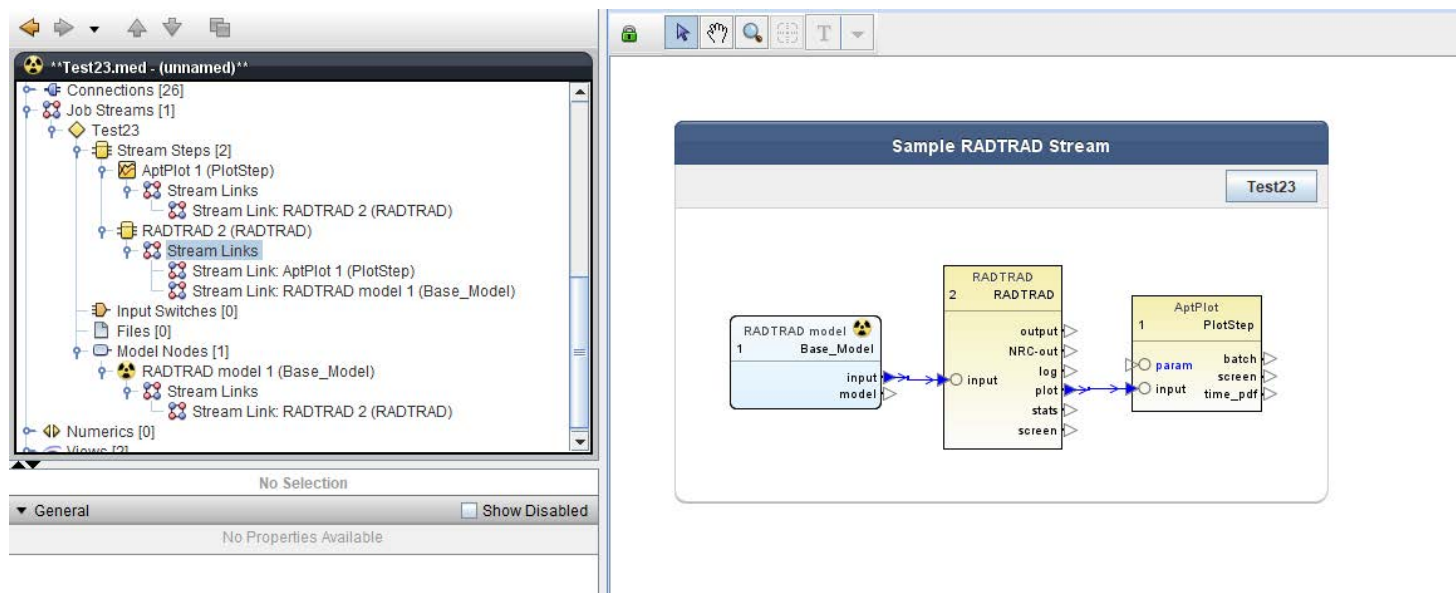
Time h	X/Q s/m ³
0.0	1.35E-4
8.0	1.0E-4
24.0	5.4E-5
96.0	2.2E-5

Sort Add Remove

OK Cancel

X/Q Input

SNAP/RADTRAD Model Editor (Test 23)



SNAP/RADTRAD Testing

- Testing was done on SNAP/RADTRAD by developing problem sets and running them with SNAP/RADTRAD. Then, a mathematical model of the same problem was programmed into Mathcad and the results compared.
 - Mathcad Version 14 used.
 - Generally relied on the AdamsBDF solver in Mathcad.
 - Interfaces with spreadsheets for problem input, radionuclide data and dose conversion factors used.
 - Comparisons made in terms of relative error. Calculations of maximum, minimum, averages of the error along with plots and results inspections used to judge the fidelity of the results.

SNAP/RADTRAD Testing

Over 60 RADTRAD problems tested. Scope of testing includes:

- Inter-compartmental Transfer
- Production Processes – TID-14844 and NUREG-1465 release models, ICRP-38 DCFs with corresponding FGR11&12 DCFs
- Decay – with and without daughters, release delay
- Removal within a compartment – aerosols (user-specified removal rates, Henry's model, Power's model)
- Removal within a compartment – elemental iodine (user-specified removal rates, Power's model)

SNAP/RADTRAD Testing

Over 60 RADTRAD problems tested. Scope of testing includes:

- Removal Processes – Flow Pathways – filters, piping (user-specified removal coefficients, Brockman/Bixler model)
- Control Room – intake/exhaust from environment, internal recirculation with filtration, flow pathway filtration
- Multiple source terms, multiple compartment pathways
- Various source term models – fuel handling accident, steam generator tube rupture, tritium release, rod ejection/control rod drop accident

SNAP/RADTRAD Testing

- Error Results for the Exclusion Area Boundary Based on Dose Results

	Error Range (%)			
	EAB		EAB	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error (%)	3.59	1.24E-03	3.63	1.56E-03
Min Error (%)	1.78	8.38E-06	2.88	2.61E-06

- Error Results for the Low Population Zone Based on Dose Results

	Error Range (%)			
	LPZ		LPZ	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	5.38	3.34E-03	5.38	3.17E-03
Min Error Range (%)	1.78	1.70E-06	2.88	2.36E-06

SNAP/RADTRAD Testing

- Error Results for the Control Room Based on Dose Results

	Error Range (%)			
	Control Room		Control Room	
	Thyroid		TEDE	
	Max	Min	Max	Min
Max Error Range (%)	9.95	2.64E-01	13.75	3.20E-01
Min Error Range (%)	0.94	2.92E-05	1.03	2.92E-05



SNAP/RADTRAD Testing

- Overall Averages based on Dose Results Comparisons:

	Average of Averages (%)	
	EAB Thyroid	EAB TEDE
Avg Error (%)	0.41	0.54
	LPZ	
	Thyroid	TEDE
Avg Error (%)	0.42	0.49
	CR	
	Thyroid	TEDE
Avg Error (%)	0.49	0.49

Future Plans

- Continue to resolve issues raised by users.
- Features that may be incorporated into future versions:
 - Better specification of input for problems involving reactor coolant
 - Currently volume units are used (ft^3 , ft^3/min). Works because f/V (1/hr) is the key parameter.
 - Mass units would be more convenient
 - Make the use of user-specified RCS activities more apparent
 - Update to current standards:
 - Ex: ANS/18.1 for the specification of RCS coolant activity was reactivated.
 - Standards should be consistent across codes used in RAMP (ex. GALE).

Future Plans

- Features that may be incorporated into future versions:
 - Updated dose conversion factors possibly based on ICRP 103
 - Improve performance of adaptive time stepping algorithm
 - Integrate the original and NRC output files
 - Automatic interface with other RAMP codes possibly using spreadsheets generated as part of the output.